

# VERITAS OVERVIEW

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**University of Delaware**

**Fermi/HAWC/VERITAS Workshop  
University of Maryland, February 2014**



# AAAAAVERITAS OVERVIEW

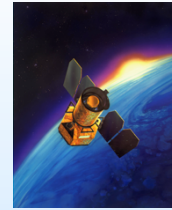
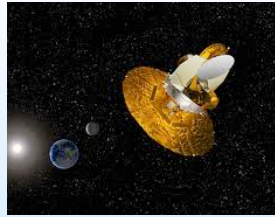
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radio

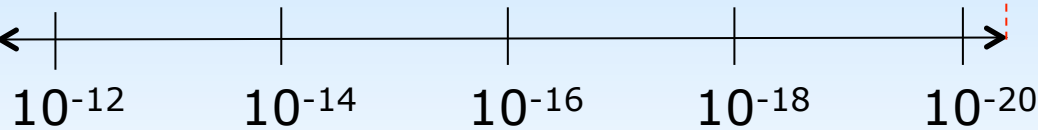
microwave

infra-red

optical

UV

X-RAY



GBM

LAT

VERITAS

HAWC

0.5 MeV

100 TeV

# VERITAS

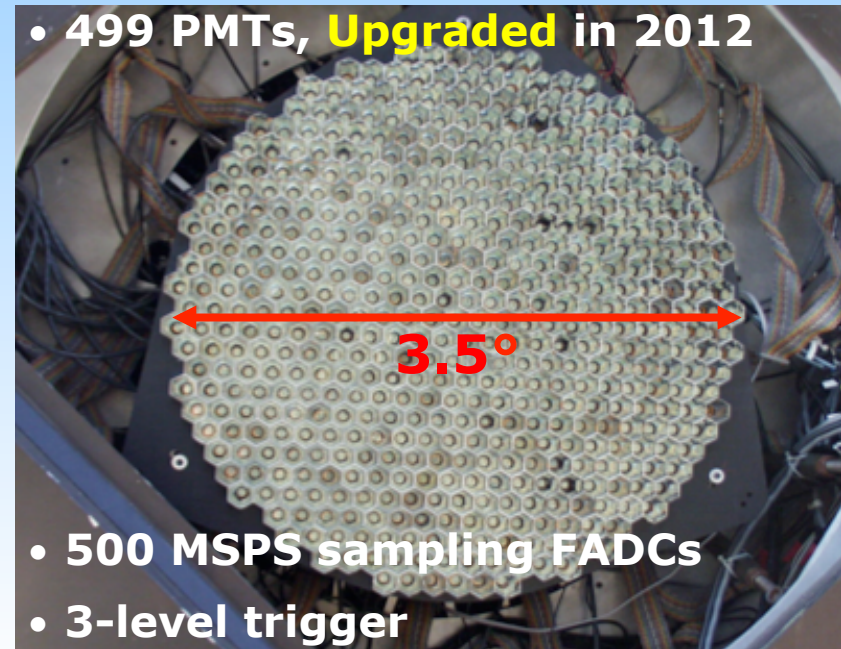
- Situated at 1250m altitude at the Whipple Observatory in Arizona
- Fully funded by NSF, DoE and Smithsonian through 2016



- 111m<sup>2</sup> tessellated mirrors
- Recoated every ~2 years



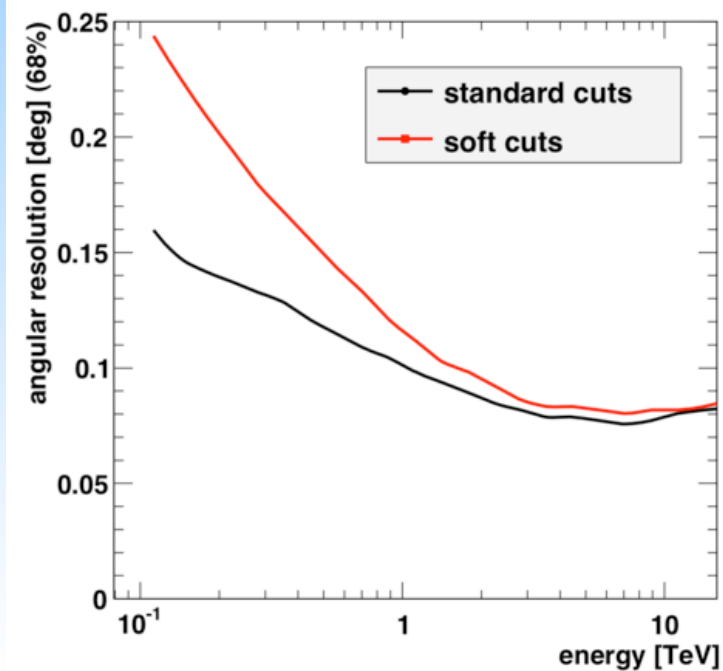
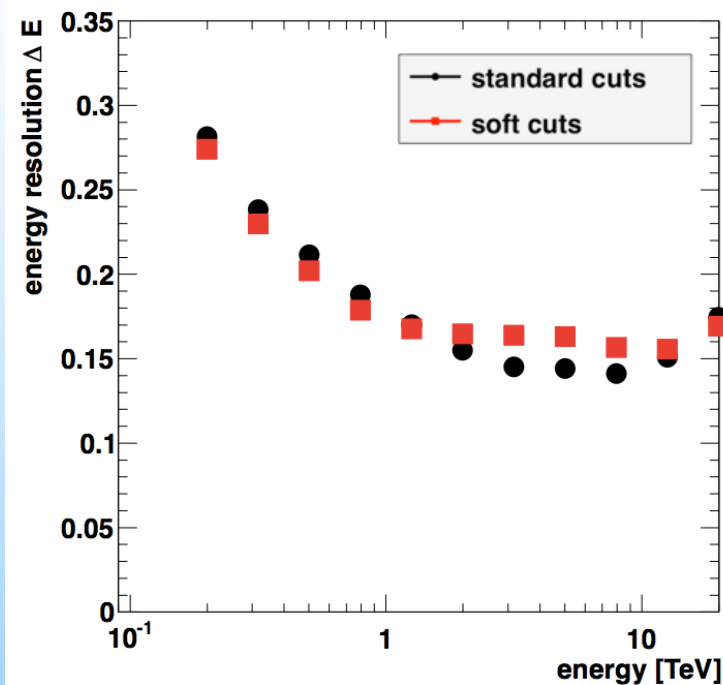
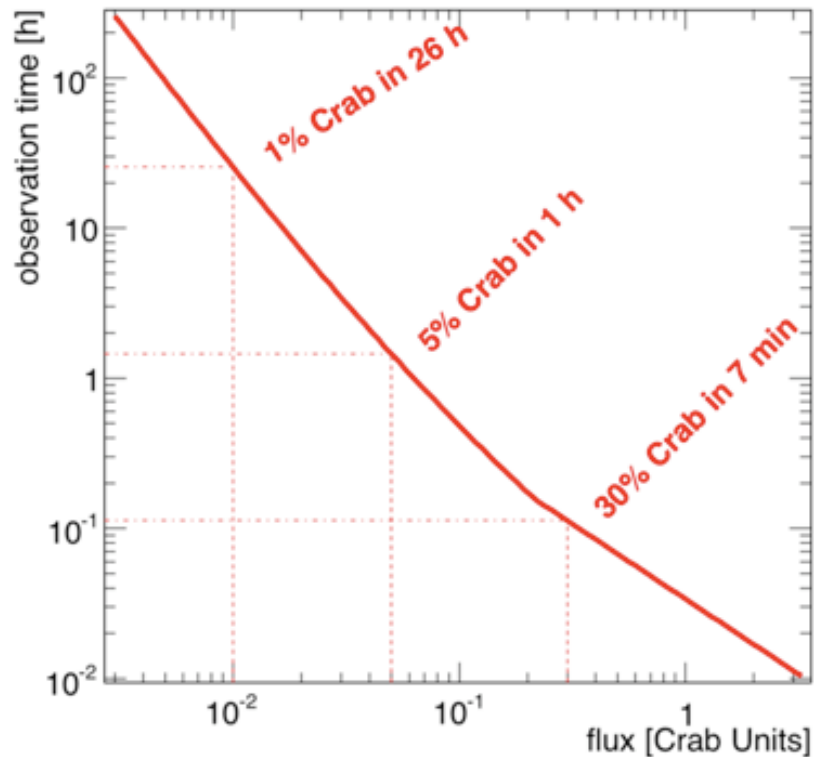
- 499 PMTs, **Upgraded** in 2012



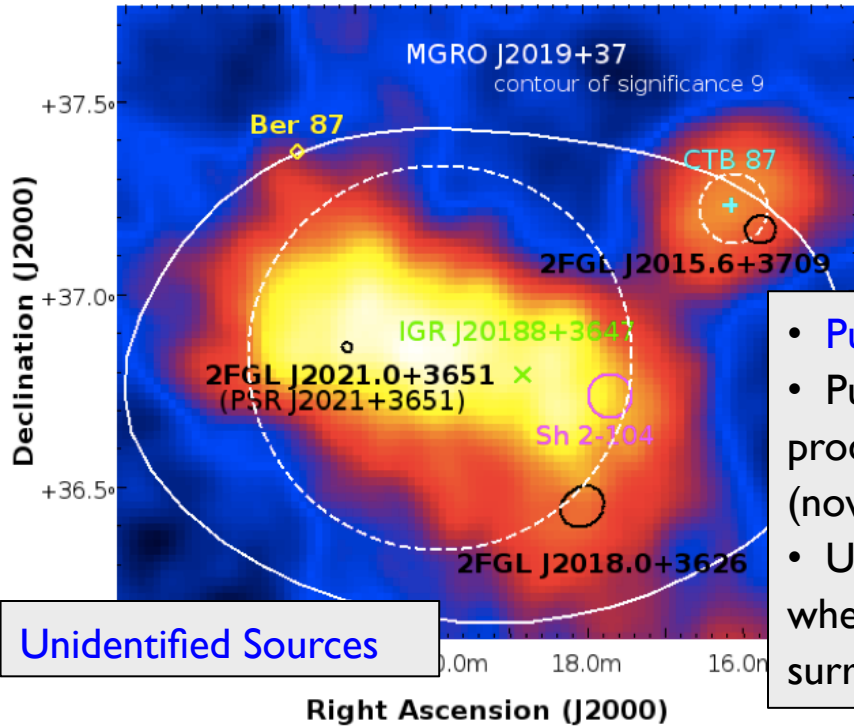
- 500 MSPS sampling FADCs
- 3-level trigger

# VERITAS Performance

- Sensitive to 1% Crab in  $\sim 25$  hours
- Angular resolution  $\sim 0.1^\circ$  (68% containment)
- Energy resolution  $\sim 15$ -20% above 300GeV

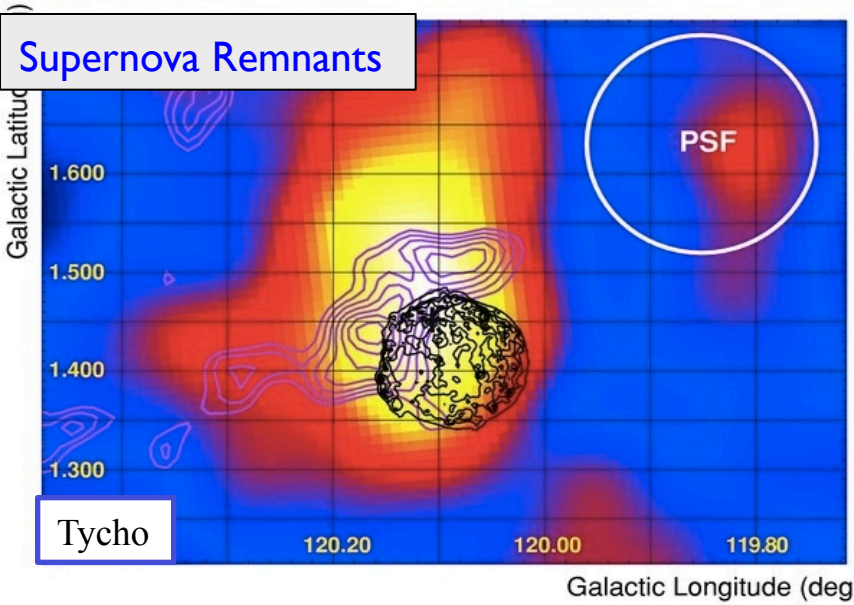
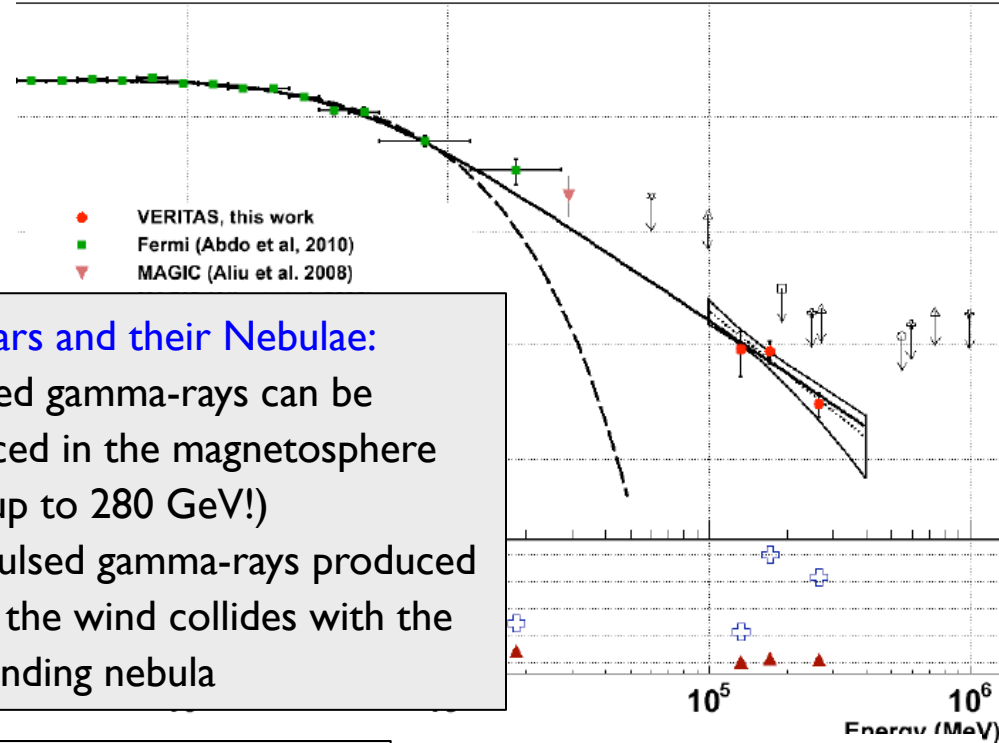


# Galactic Sources



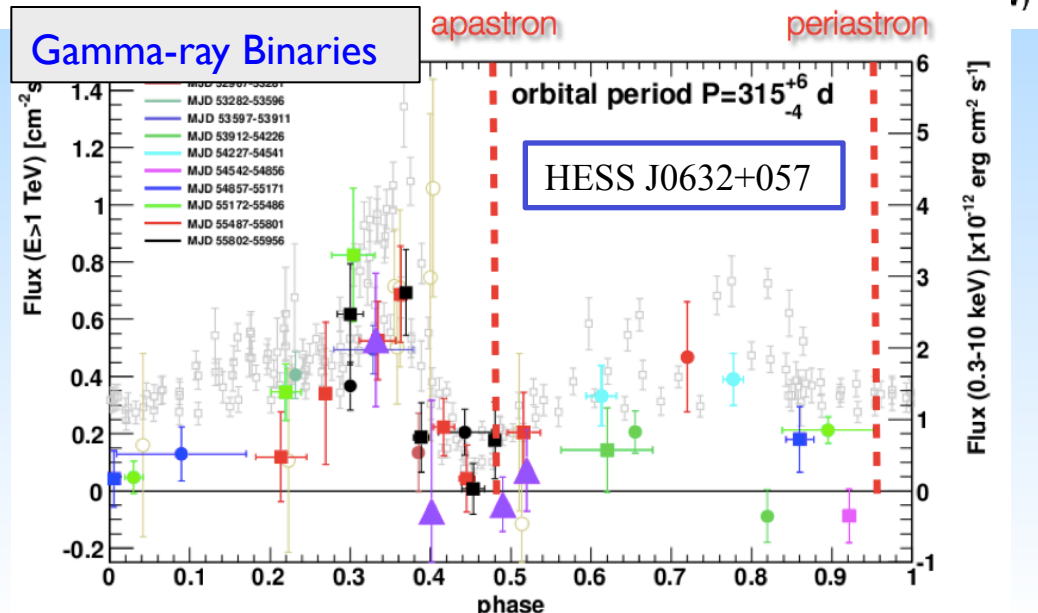
Unidentified Sources

- Pulsars and their Nebulae:
- Pulsed gamma-rays can be produced in the magnetosphere (now up to 280 GeV!)
- Unpulsed gamma-rays produced where the wind collides with the surrounding nebula



Supernova Remnants

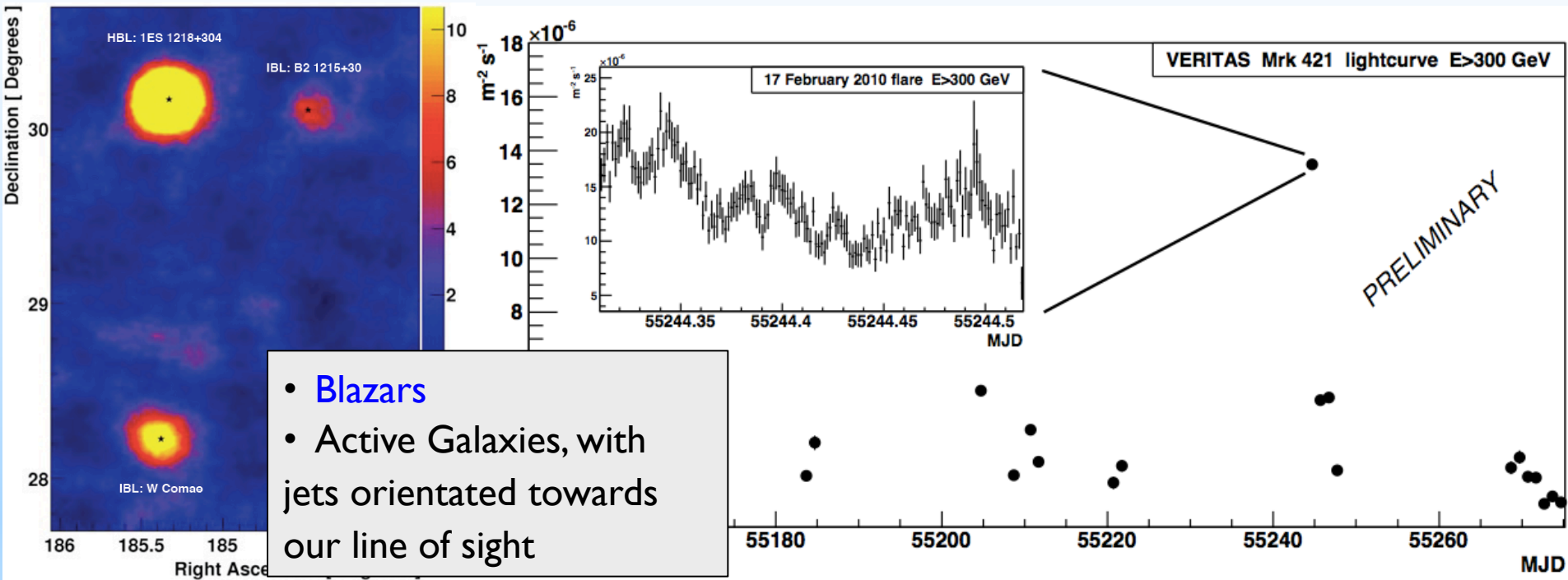
Tycho



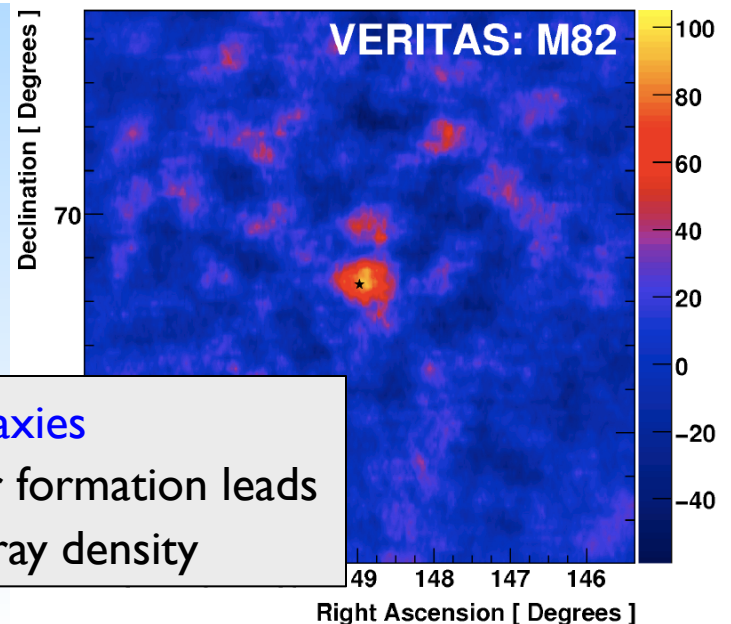
Gamma-ray Binaries

HESS J0632+057

# Extra-Galactic Source Classes

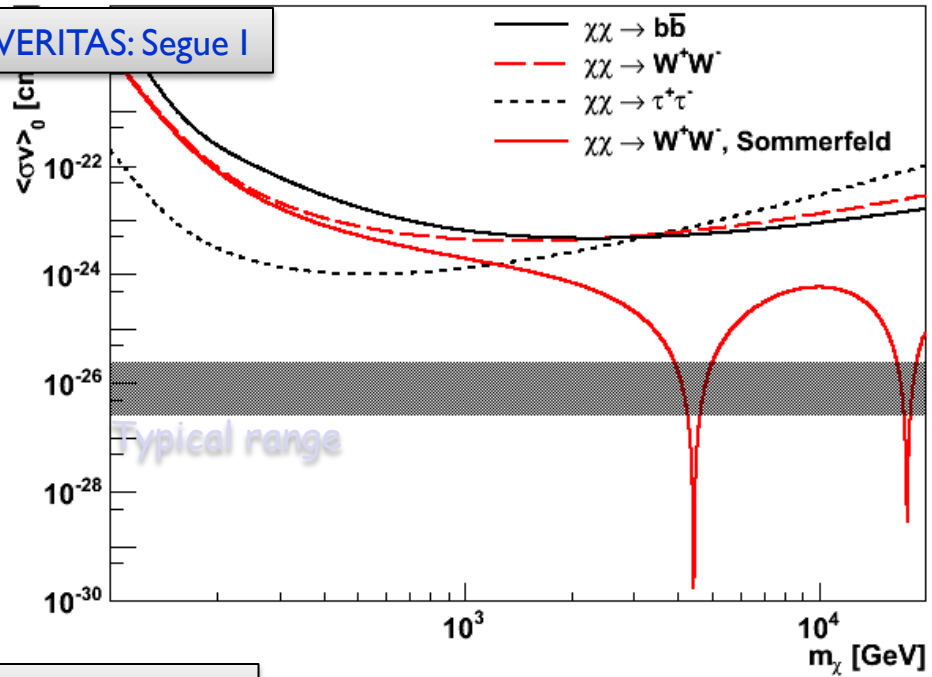


- **Radio Galaxies**
- Close, with misaligned jets

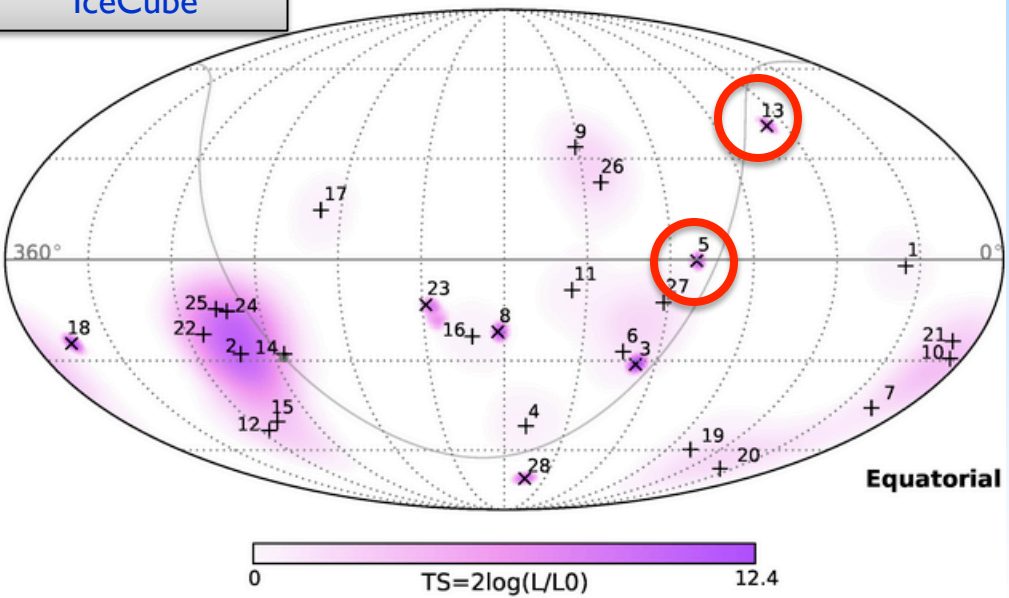


# Astroparticle Physics, Cosmology & Multimessenger

VERITAS: Segue I



IceCube



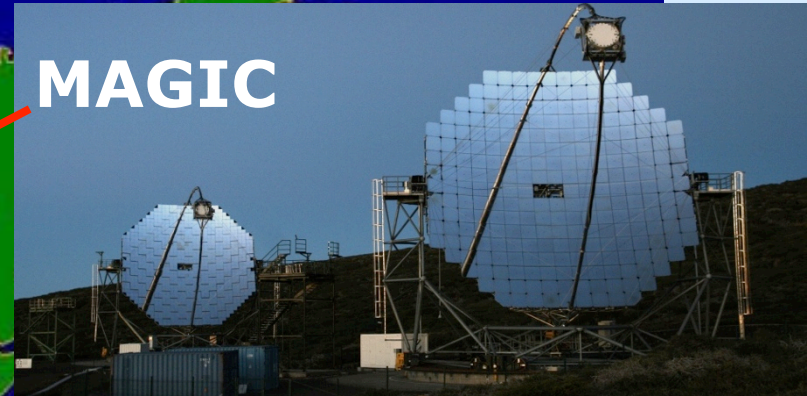
- Dark matter searches
- Lorentz Invariance Violation
- Primordial Black Holes
- Extragalactic Background Light
- Intergalactic Magnetic Fields
- Direct Cherenkov emission
- Electron-positron measurements
- Neutrino/ UHECR/ Gravitational Wave Correlations



**VERITAS**

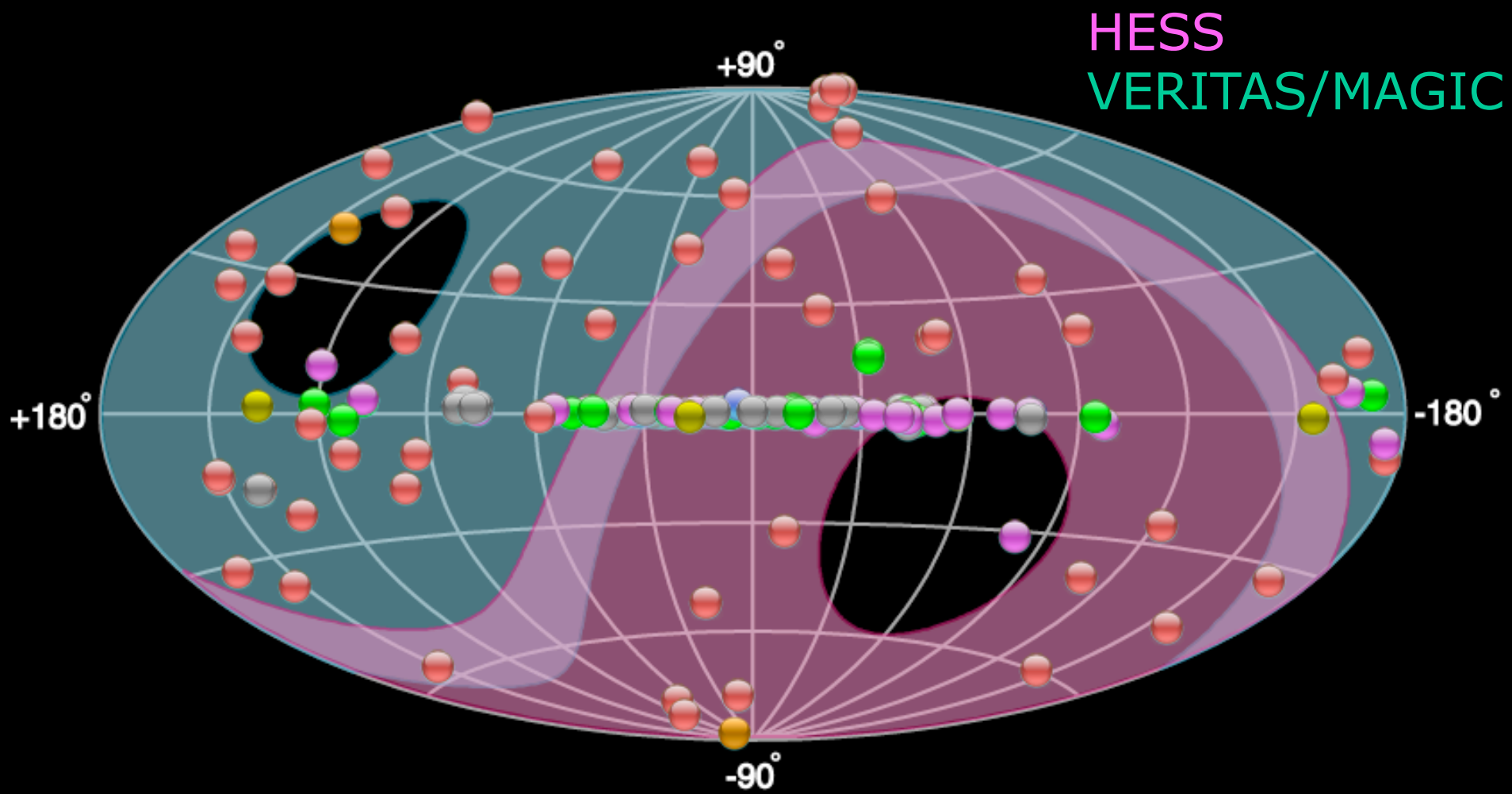


**MAGIC**



**H.E.S.S.**







PKS 2155-304



Cygnus

Mrk 501

Mrk 421

3C66A

Crab

Sept

Aug

July

June

May

Apr

Mar

Feb

Jan

Dec

Nov

Oct

PKS 2155-304

Summer shutdown

32°N,  
111°W



19N,  
97°W

Get directions My places

Green Valley, AZ  
Parque Nacional Pico de Orizaba  
Add Destination - Show options

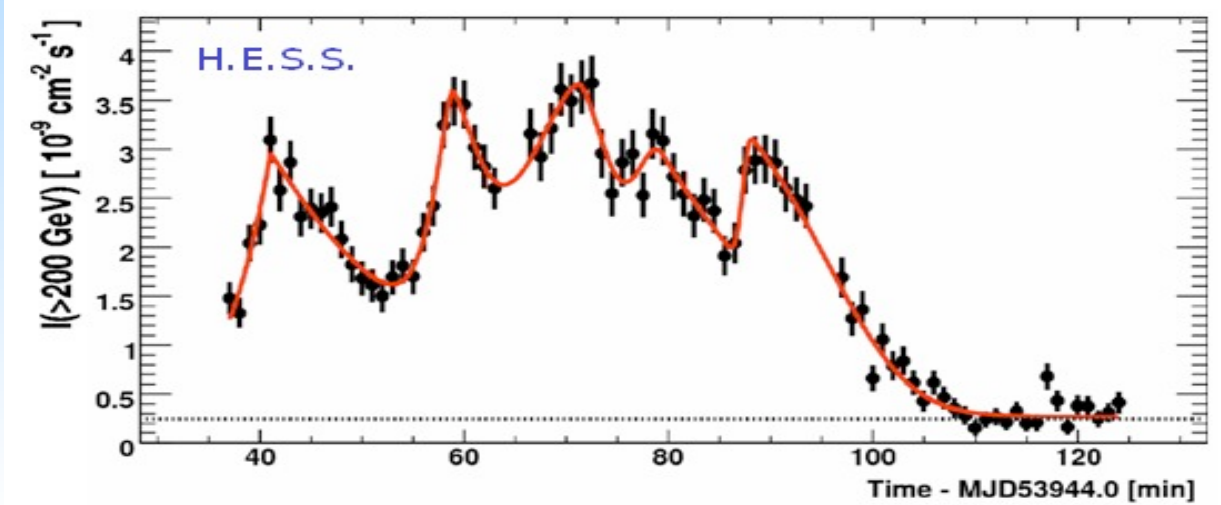
**GET DIRECTIONS**

Suggested routes

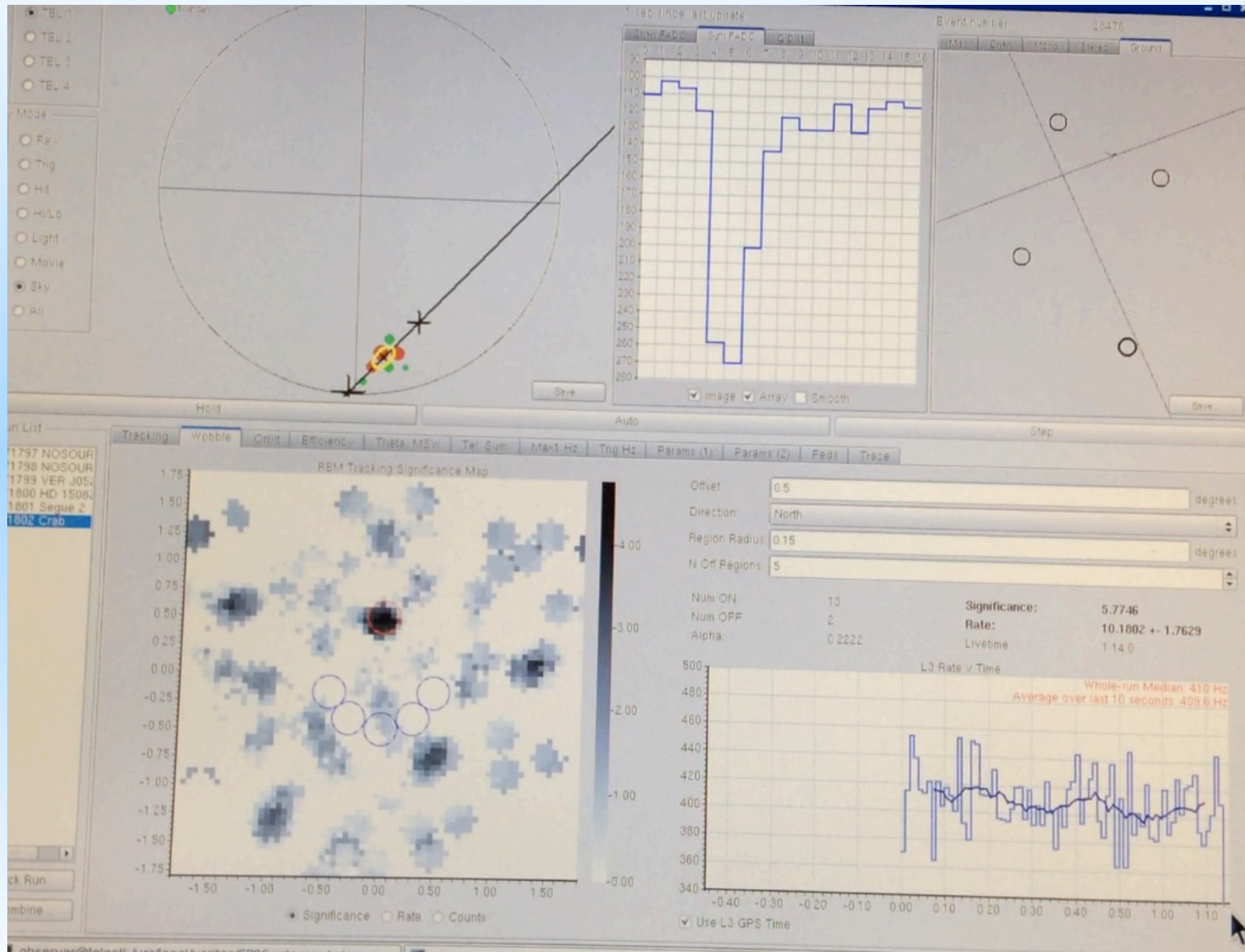
Mexico 15 S	1,539 mi, 25 hours
Carretera Federal 49	1,500 mi, 25 hours
I-10 E	1,666 mi, 27 hours

Driving directions to Parque Nacional Pico de Orizaba

This route has tolls.

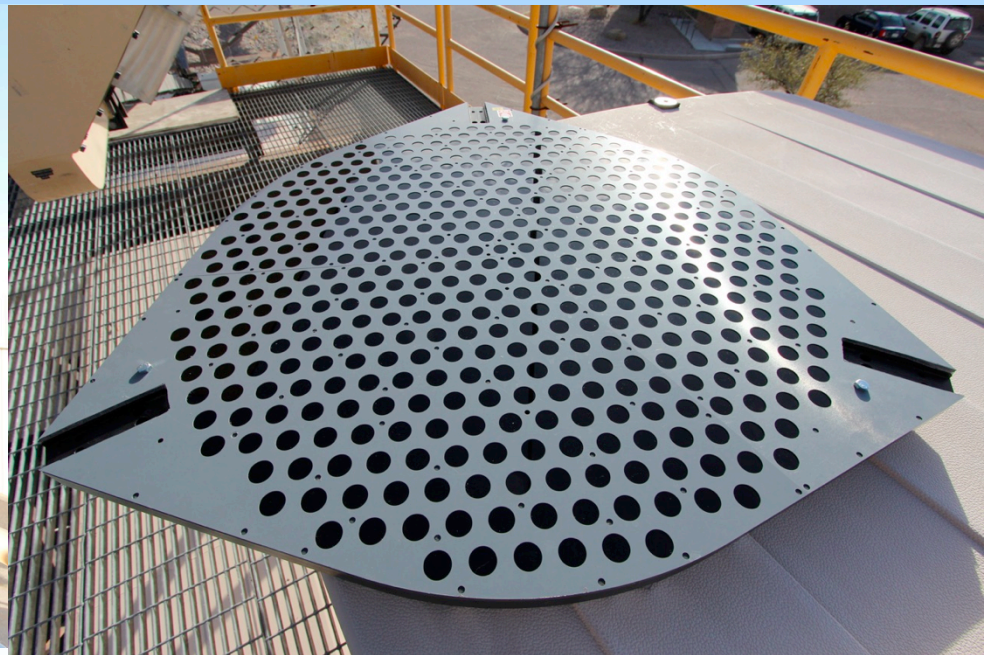
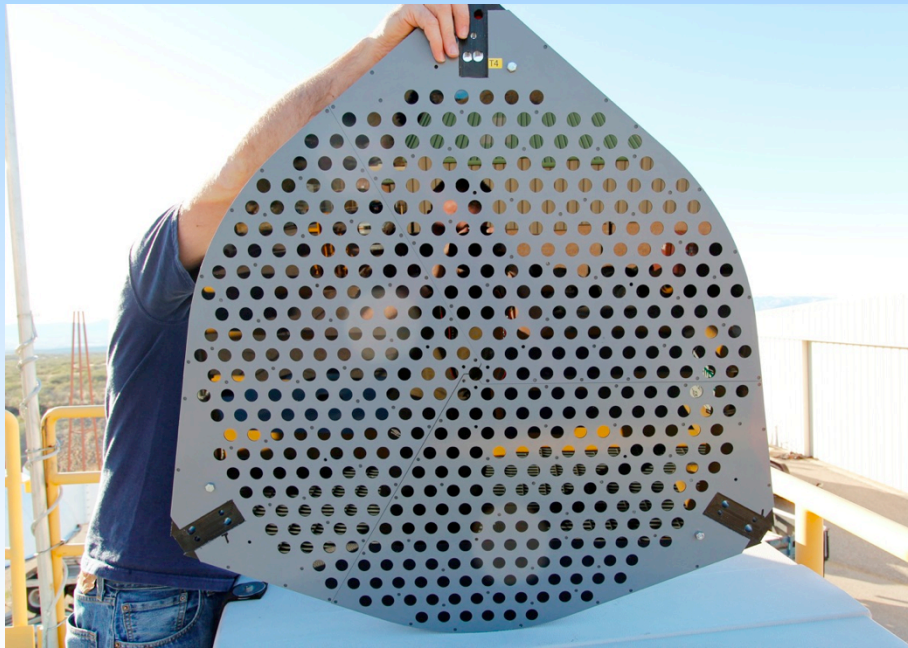
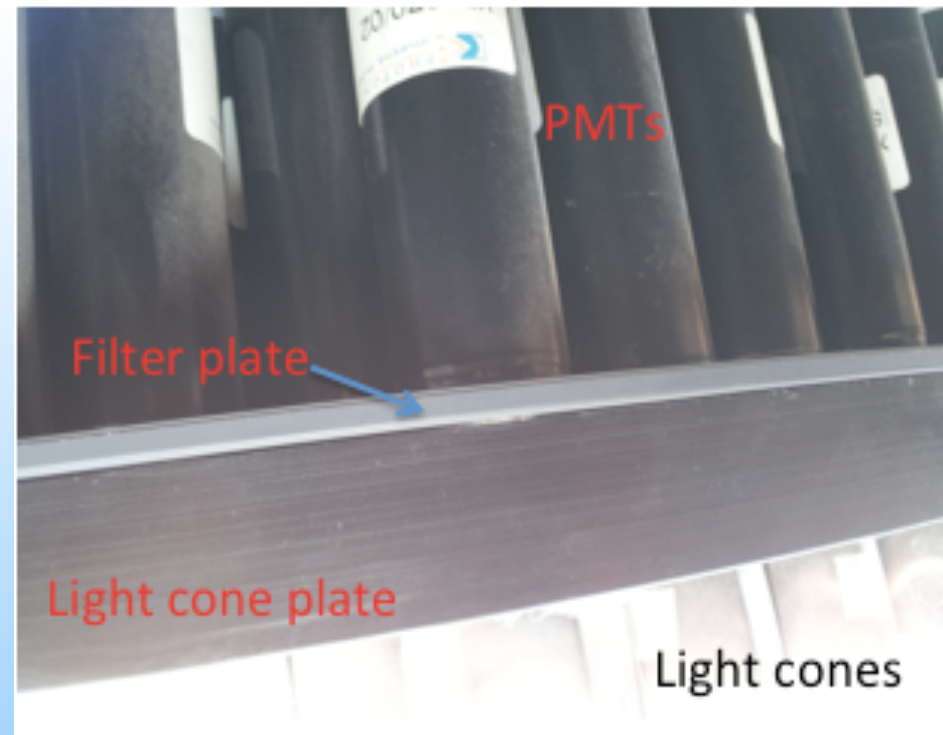


# What can we do?



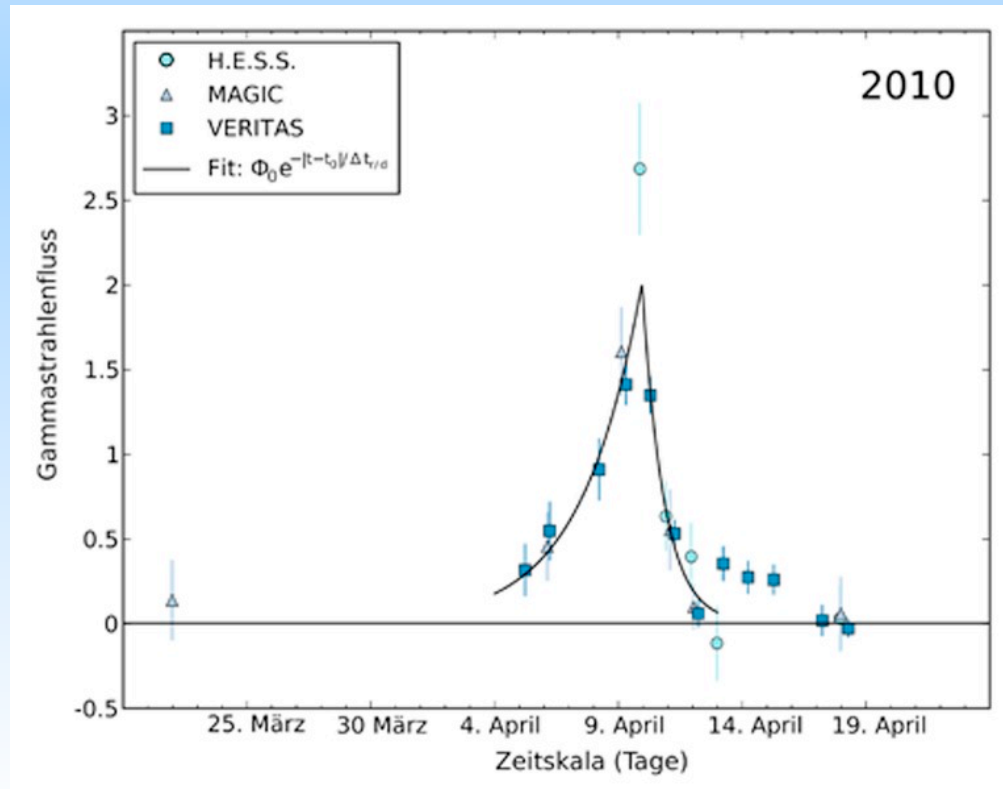
# What about the Moon?

- Whipple never observed under moonlight
- VERITAS now only stops for ~3 days per month (~50% moonlight observations)!
- Standard observations up to ~ 35% moon
- Reduced HV for 35% - 65% moon
- UV-pass filters for >65% moon
- Even full moon observations are possible!



# Collaborating with VERITAS

- Write a proposal with a full VERITAS member (“one-off” collaboration)
- Apply to the Fermi-VERITAS program
- Apply to become a VERITAS Associate (full access to VERITAS data and web pages, sign all papers which you contribute to directly)
- Become involved in large multi-wavelength campaigns (e.g. M87, Markarians)
- Talk to us!





# VERITAS-Fermi Collaborative Program

## The VERITAS Collaborative Program

The combination of very high energy (VHE;  $E > 100$  GeV) and high energy (MeV to GeV) gamma-ray observations is a powerful method with which to view the universe. Towards this end, the [Fermi](#) and [VERITAS](#) projects have established a pilot program to support collaborative efforts to observe Fermi sources which will be awarded on a competitive basis. The programs that will be supported are those that are enhanced by the combination of Fermi observations with VHE observations made by VERITAS. The philosophy of the approach, in keeping with the missions of both Fermi and VERITAS, will be that of maximum scientific return for the entire scientific community.

- Up to 15% (120 hours) of VERITAS observing time is available
- Maximum allocations per RA band
- Science is reviewed by the Fermi GI panels (not VERITAS)
- Funding!

RA Band	Available Time (hours)
0 - 2	8
2 - 4	16
4 - 6	24
6 - 8	22
8 - 10	17
10 - 12	28
12 - 14	23
14 - 16	13
16 - 18	11
18 - 20	14
20 - 22	14
22 - 24	11
<b>Total</b>	<b>Not to exceed 120 hours</b>

# VERITAS-LAT MoU

1. The LAT team will make a best effort to provide the VERITAS team any information that would be useful for VERITAS planning and operations. Such information would include information about flares (including those with flux below the public release threshold) and information about sources with hard spectra in the LAT energy range.
2. If the LAT team identifies sources as potential VERITAS targets and communicates these sources to the VERITAS collaboration, the VERITAS collaboration will make a best effort to observe these targets taking into consideration the scientific merit of the observations. The VERITAS collaboration will inform the LAT team of the results of the observations.
3. Any shared information that is not public (from either group) will be treated in confidence by both the collaborations. The initial exchange will be limited to a small number of contact persons, including the spokesperson and the multiwavelength coordinator, until a decision to proceed with an analysis is made. Group members will be cautioned not to share these results outside the collaborations in any form, including publications, Web sites, e-mail, ATELS, or seminars. This agreement does not prevent either collaboration from publishing their own data.
4. If scientific results would be enhanced by a joint publication, then authorship will be open to all members of both collaborations.

# VERITAS-HAWC MoU

1. A joint scientific program of gamma-ray observations is planned between the HAWC and VERITAS Collaborations. It is foreseen that HAWC will provide all-sky monitoring for detection of strongly flaring sources in the TeV energy range, and detection of angularly extended, diffuse emission sources, and that VERITAS will perform TeV gamma-ray follow-up observations. Information from VERITAS will be provided to HAWC regarding the discovery of bright flares from known sources, and, with the approval of the VERITAS Science Board, other transient events. Details of the program (trigger thresholds, exposure time allocations, etc.) will be defined through discussion, and detailed proposals to the VERITAS Time Allocation Committee, co-authored by VERITAS and HAWC Collaboration members. Rapid follow-up observations can also be accomplished through the use of the VERITAS Spokesperson's discretionary time allocation.

2. If the HAWC team identifies a potential target for VERITAS observations, the VERITAS collaboration will make a best effort to observe the target, taking into account the observing schedule and competing constraints. If VERITAS observations are made, the VERITAS team will inform HAWC of the results of the observations prior to making them public. This exchange of information will be made with sufficient time to agree on a joint result and consider a possible joint announcement and/or joint publication.

3. If the VERITAS team identifies a potential target for HAWC observations, the HAWC collaboration will make a best effort to keep their instrument in data recording mode for follow-up observations. If successful HAWC observations are made on this source, the HAWC collaboration will inform VERITAS of the results of these observations prior to making them public. This exchange of information will be made with sufficient time to agree on a joint result and consider a possible joint announcement and/or joint publication.

4. Any shared information that is not public (from either group) will be treated in confidence by both collaborations. Group members will be cautioned not to share these results outside of the collaboration in any form, including publications, web sites, e-mail, ATELS or seminars.

5. This agreement does not prevent either collaboration publishing their own data independently; however, if both collaborations agree that the scientific impact of the **results would be enhanced by a joint publication, then authorship will be open to all members of both collaborations**

The MoU's **do not** relate to any specific science goals or targets (e.g., they do not refer only to flaring sources)

They provide a framework which allows us to talk to each other.

Essentially – if either partner provides privileged (unpublished) notification of anything, the information will be held in confidence, results will be shared and a publication/ announcement strategy agreeable to both partners will be developed.

# Practical programs

- MAGIC/HESS/VERITAS/HAWC agreement on known TeV blazars
- The alert criteria are:
  - 3 Crab units in the case of Mrk 421 and Mrk 501
  - 4 sigma per night for M87 & IC 310 (corresponding to a flux of roughly 7% Crab units)
  - 0.5 Crab units in the case of all other known (in VHE gamma-ray band) extragalactic objects...

# Some other examples

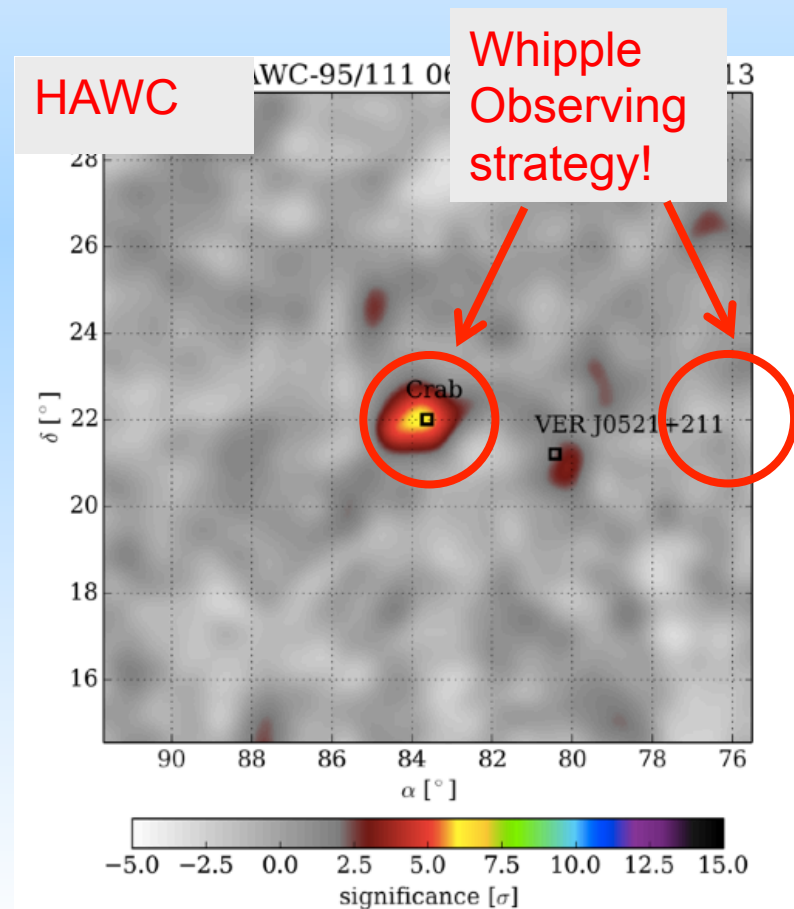
- RGB J0710+591 (HBL,  $z=0.125$ )
- VERITAS detected - alerted the LAT team

- RBS 0413 (HBL,  $z=0.19$ )
- VERITAS and LAT detected - joint ATEL

- VER J0521+21 (RGB J0521.8+2112)
- Identified as a hotspot in  $>30\text{GeV}$  map

- My favorite
  - RGB J0152+017
  - VERITAS noticed it on the Swift schedule and observed.
  - A hint, but didn't quite cross the detection threshold
  - Informed HESS that they might like to announce it soon!

- PKS 1424+240 (IBL/HBL, most distant TeV source!)
- First LAT-motivated VERITAS detection (identified in BSL)



# Summary

- VERITAS provides a very rapid, very sensitive response to alerts
- Our angular and spectral resolution are good, which is critical to identify sources, to resolve confused regions, and to study structure in extended sources
- There are many ways to collaborate with us!
- The TeV/ GeV community is generally more open to rapid collaboration than in the past

